lying scud was noted through office windows at 4:03 p. m., just east of the station. Clouds moved in opposite parallel paths, one from the north and one from the south. *These opposite parallel currents were so arranged that if any right-hand deflection took place a dimuntion of air pressure would develop between them.* After a short interval, a vortex apparently formed without a funnel cloud. Under the vortex débris rose, appearing like cinders or light trash ascending to the clouds. After observing this for about one minute both station employees ascended to the roof of the Federal building for better observing. Open sky was noted to the north, east, and south near the horizon, but the horizon was obscured to the west. The break in the clouds near the horizon afforded an excellent opportunity for observation of the formation of the small but energetic tornado whirl, and the light from the break probably diminished the dark hue of the clouds as they seemed more slate-colored than tornado clouds are usually described. Light thunder and lightning were recorded near the beginning of the storm.

The converging and turmoil of the clouds were observed from the roof of the building by Weather Bureau employees for about one minute. The movement was east-southeast. A short, heavy rain and light hail lasted about one minute at this time. After the ending of the rain, skies began to clear on the western horizon and darken on the eastern.

The first actual destruction, as witnessed by Weather Bureau employees, took place at 4:04 p. m. Houses were reported damaged a little earlier at 814 Wheeler Avenue, near Emma Street, at 4:02 or 4:03 p. m. Unofficial reports from persons in the open indicated a cloud at this time, but it is hard to determine whether they saw a tornado cloud or the turbulent cloud activity, but the latter is thought to be the case. At 4:04 p. m. the débris shot upward under the vortex in a cloud of dust. The ascending wreckage had the appearance of a great explosion or sparks from a great fire and was distributed in horizontal strata until drawn into the vortex. Watching the successive ascending phenomena gave one the impression that the seat of energy was above the earth and the ground features were the result of suction. These formations appeared three successive times, without a tornado cloud being formed. Each successive formation seemed to accumulate strength and to produce worse effects than the preceding one. Effects were very similar to blasting operations. The time interval between the first and second was about 1 minute and between the second and third about 30 seconds.

The fourth ascending formation was marked by a descending cloud resembling a misshapen cornucopia which failed to reach the ground, and was accompanied by a larger amount of dust and wreckage. This dissipated after about one minute and re-formed. The fifth formation, or second funnel cloud, appeared as two large bells top to top with a thin ropelike pendant connecting them. This was the most distinct, sharply defined, and beautiful of the entire series and lasted only a few seconds. The sixth formation and third funnel cloud formed in a few seconds. The ascending débris reached the dimensions of a giant explosion. The formation widened, accompanied by rain and a cloud of débris, and moved slowly to the northeast, finally disappearing. The greatest destruction occurred with the sixth ascending phenomenon. Airplane observations afterwards showed that the path narrowed before the storm dissipated, which feature could not be observed from the roof of the building. Débris lay in practically straight lines parallel to the path of the storm for the last quarter of mile of the path. Sounds, as heard at some distance from the storm, resembled the hum of a motor, but they were quite harsh and loud near the storm area.

An imposing display of towering cumulus and cumulo-nimbus clouds was observed in the direction in which the tornado disappeared, resembling cumulus formed over great fires. The pictures of the tornado at Austin, Tex., May 2, 1922,[2] would almost fit the tornado at Fort Smith, April 12, 1927.

The path of the tornado was not more than 4 miles long and about 150 yards wide. The tornado varied in strength and direction throughout its path. The path ran generally from the southwest to the northeast and lay about one-half mile east of the tornado of January 12, 1898.[3] Two persons were killed and 13 injured seriously enough to require hospital attention. The damage was estimated at $100,000. The strength of the storm was only moderate for a tornado, with only a few examples of total wreckage. Houses were unroofed, awnings torn down, fences moved, trees uprooted, garages destroyed, and light buildings moved from foundations. Absence of marked tornado freaks was also noted.

Few freak conditions, often reported from tornado districts, could be found. A child was taken up by the wind, carried for 3 miles, and let down scratched but not injured. A woman, evidently killed in the tornado area, was found 7 miles away. A number of automobile tires were carried a mile and dropped. A heavy timber, 14 by 14 inches and 12 feet long, was carried half a mile south of town. Hundreds of chickens disappeared and engines were stripped from automobiles. There was no way even to estimate the excessive wind velocity, but the photographs [not reproduced here] make it certain that it was hundreds of miles per hour.

[2] Monthly Weather Review, May, 1922, 50: 252–253.
[3] Monthly Weather Review, January, 1898, 26: 18–19.

VARIABLE FEATURES OF BAROMETRIC DEPRESSIONS AND ANTICYCLONES AS A BASIS FOR SEASONAL FORECASTING

By N. A. Hessling

[In charge of daily forecasting service of the Argentine Meteorological Office]

For a country like Argentina, with *extensive* rather than *intensive* farming, seasonal forecasts would undoubtedly be of much more practical use than daily forecasts of the weather. For this reason, for some time, I have been trying to find a basis for such forecasts. Correlations between different meteorological elements in various parts, along the lines followed by Walker in India, have been found, but they are generally too vague to be of any practical value, at least by themselves, and the same may be said of relations with sun spots, solar radiation, etc.

Since I have been engaged in daily forecasting of the weather, I have been struck by the remarkable tendency of certain types of pressure distribution and weather to repeat themselves in some years or seasons, while in other years the opposite types are more frequent. Some types bring dry weather and others wet weather, and the prevalence of each type determines the dryness or wetness

of the season. The persistence of certain types for long periods indicates that their cause must be some general condition, probably connected with the general circulation of the atmosphere, and this suggests that by studying these types we might find a basis for seasonal forecasting.

With the object of confirming this hypothesis, computations were made of the mean latitude of barometric depressions and anticyclones, the frequency of certain typical tracks in different seasons, and other characteristic features that could be correlated with the rainfall and temperature of the same and following seasons. The results have really been better than I expected, the rainfall of autumn, winter, and spring giving correlation coefficients of 80 per cent and over when compared with some features of the depressions or anticyclones of the preceding season.

The results have been published in detail in the Monthly Bulletin of the Argentine Meteorological Office (in Spanish), but as it is thought that they may be of a more general interest, a short abstract is herewith given.

The mean latitude of centers of barometric depressions (when first observed) in winter and summer seems to give a fairly close representation of the rainfall to be expected in the following spring and autumn, respectively. In Tables 1 and 2 the corresponding values are given, the rainfall at Buenos Aires having been chosen. The correlation is larger than this at some stations and smaller at others.

TABLE 1

	Mean latitude of depressions in summer (December to February)	Total rainfall at Buenos Aires in autumn (March to May)
		Millimeters
1913–14	31. 8	597
1914–15	29. 9	244
1915–16	29. 3	174
1916–17	30. 3	227
1917–18	29. 9	140
1918–19	30. 7	388
1919–20	29. 9	282
1920–21	30. 4	326
1921–22	30. 4	243
1922–23	29. 1	260
1923–24	29. 3	184
1924–25	30. 3	341
1925–26	30. 7	347

Correlation coefficient, 0.84.

TABLE 2

	Mean latitude of depressions in winter (June to August)	Total rainfall at Buenos Aires in spring (September to November)
		Millimeters
1913	30. 0	463
1914	29. 4	414
1915	29. 0	238
1916	24. 2	133
1917	26. 0	98
1918	28. 5	211
1919	28. 6	355
1920	27. 0	341
1921	27. 4	202
1922	24. 9	193
1923	25. 9	203
1924	26. 0	165
1925	29. 3	377
1926	27. 6	189

Correlation coefficient, 0.79.

For the winter rains the behavior of anticyclones seems to be a better guide than that of depressions. The anticyclones observed in the Argentine are always quite formed when crossing the borders, the depressions, on the other hand, in most cases forming within the country, except those crossing the southernmost portion, which have not been taken into account in this study.

By their point of origin the anticyclones that cross Argentina may be divided into two principal classes, those that come from the Pacific and apparently are offshoots of the permanent South Pacific anticyclone, and those that come from the Antarctic regions and which probably are offshoots of the great anticyclone that is supposed to lie over the South Pole.

The most frequent tracks of anticyclones are in a northeasterly direction, crossing Argentina into Uruguay or Brazil. In certain years the tracks show a more northerly trend, the centers passing latitude 35° west of the sixty-fifth meridian, after which they either continue farther north or turn to the east. Some anticyclones pass with their centers along the Atlantic coast, this type being most frequent in spring and summer.

As will be seen from Table 3, the amount of rainfall in the winter months may be foreseen approximately in the autumn, taking into account either the number of anticyclones appearing south of 45° latitude, the mean latitude of all anticyclones when crossing the western border, the frequency of anticyclones having a northerly and oceanic track, or those having the normal northeasterly track. The correlation coefficient is positive with the first three values and negative with the fourth.

TABLE 3.—*Relation between positions of highs in the autumn (March–May) and the rainfall of the succeeding winter in Buenos Aires*

Year	A Frequency of HIGH centers south of latitude 45°	B Mean latitude of all HIGHS when entering Republic	C Frequency of HIGHS with northerly and with oceanic tracks	D Frequency of HIGHS with northeasterly tracks	E Total rainfall in Buenos Aires in winter (June to August)
					Millimeters
1913	1	39. 0	2	11	140
1914	4	41. 0	8	2	460
1915	0	38. 9	2	14	50
1916	0	35. 3	0	16	11
1917	4	40. 6	4	6	206
1918	3	39. 1	1	14	75
1919	3	39. 7	6	7	211
1920	0	37. 7	1	13	48
1921	1	38. 7	.4	13	113
1922	7	41. 8	12	5	540
1923	3	39. 4	8	6	307
1924	2	38. 0	8	13	76
1925	5	41. 5	9	7	94
1926	3	40. 0	11	7	188

Correlation coefficient:
A–E _____ 0. 76
B–E _____ .70
C–E _____ .67
D–E _____ −.84

It will be noticed that the winter rainfall agrees fairly well with what might be expected according to the trend of the anticyclones in the autumn, except in the year 1925, when the rainfall was less than would have been expected. It is noteworthy, however, that although the rainfall was below normal that winter, the humidity and cloudiness was among the highest in this series of 14 years, so it could not really be classified as a dry winter.

For the summer rainfall no very marked correlation has yet been found, the mean latitude of depressions in spring giving a slight negative correlation. The largest correlation found for the summer rainfall is with the mean

latitude of anticyclones in the previous winter, this giving 0.54. This lack of result for the summer may be due to the fact that the rainfall in this season often occurs in heavy thundershowers and the variations are more irregular than in other seasons.

The temperature does not show such high correlations as the rainfall for any season, but the winter temperature compared with the trend of the anticyclones in autumn gives a coefficient of 0.71. Some results obtained lately, and which will be published in the near future, indicate that the difficulty to obtain a large correlation with the temperature is due to the complication set up by the effect of cloudiness on temperature.

It is probable that the shifting south of the barometric depressions in some seasons and of anticyclones in other seasons and the trend of the latter to move north or over the ocean are really indications of one and the same phenomenon, which may be an increased energy of the equatorial air currents as opposed to the polar air currents.

It is noteworthy that these trends of depressions and anticyclones do not show any marked correlation with the barometric pressure variations in Argentina, though it is possible they might show it with the pressure of the equatorial region of Brazil.

Further researches are being conducted along these lines, and it is hoped they may give not only practical results for seasonal forecasting, but may also throw light on some problems of the general circulation of the atmosphere and the cause of abnormalities of certain seasons.

NOTES AND ABSTRACTS

THE MASS EXCHANGE IN THE FREE AIR AND RELATED PHENOMENA [1]

The study of atmospheric turbulence has nowadays grown to a very live branch of meteorology, with numerous applications in different fields. In this development W. Schmidt, in Vienna, has played one of the foremost parts, being one of the creators of the fundamental conception "Austausch" (exchange) upon which the theory of atmospheric turbulence tests. Schmidt has made it his task to prove the fertility of this conception in a number of problems also outside pure meteorology. It is therefore most gratifying that a monograph from his hand has appeared which in a popular way treats the question of the turbulent exchange of mass in the atmosphere as well as a number of its geophysical and geographical botanical consequences.

The chief effect of the exchange of mass through a fixed horizontal unit surface in the atmosphere is, as well known, that any element the vertical distribution of which is not uniform will be subject to a vertical transport or diffusion. This transport or flow upward per square centimeter and second is equal to the product of a coefficient, A, in the rate of decrease upward of the element under consideration. The first of these factors, the "Austausch," depends solely upon the rate of mass exchange and is independent of the element discussed. The second factor depends only upon the element discussed and is independent of the mass exchange.

The above expression for the diffusion can now be applied to any property of the air that remains constant during adiabatic compression and expansion; for instance, horizontal momentum, potential (not ordinary) temperature, water vapor content (in absence of condensation), electric charge, content of dust, condensation nuclei, seed, and pollen. The theory can, of course, also be applied to turbulence in the sea. Schmidt treats in his book the effect of turbulent mass exchange on all these elements and on a number of others not mentioned here.

In the section devoted to the vertical temperature distribution, Schmidt has subjected the diurnal variation of temperature at different levels to a very illuminating study. It is shown how the actually observed oscillations are composed of two terms, one depending upon the diurnal variation of absorption and emission of radiation at that level, while the second term represents the temperature variation at the surface which is propagated upward with decreasing velocity and amplitude.

The same section also discusses the difference between continental and maritime climate. It is shown that the usual explanation of the difference between these two climatic types, which is based upon the difference between the thermal capacities of water and soil, is very unsatisfactory. The specific heat per unit volume of water is only about twice that of the soil; if the soil and the water otherwise behaved in the same way, this difference would produce a ratio of the amplitudes of the diurnal temperature variations equal to $\sqrt{2}:1$, while the actually observed ratio is many times larger. The true explanation lies in the *turbulence* of the sea, which rapidly carries the heat accumulated at the water surface downward to deeper strata. In the ground there is no such turbulence; only the extremely small molecular conduction of heat is active, at a very slow rate carrying accumulated heat downward, but leaving the greater part of it to be reradiated to the lowest atmospheric layers.

It is impossible in a short review to mention all the questions which lend themselves advantageously to a treatment by the Austausch method. Schmidt makes, after Richardson, comparisons between the upward transport of water vapor and the precipitation; these two quantities must become equal when means are formed over the globe and for a long period (for instance a year).

There is in Schmidt's book one application of the theory of turbulent diffusion, which as far as I can judge should be of the greatest value to botanists and geographers; namely, the spread of pollen and seed by wind and turbulence. Using a mean wind velocity of 6 meters per second, an "Austausch" value of 20 units, and taking into account variations in velocity of free fall for different kinds of seed and pollen, Schmidt is able to compute for each a "mean dispersion limit." He arrives at the following values:

	Kilometers
Spores of *Lycoperdon*	460, 000
Pollen of *Pinus silvestris*	40
Seed of *Taraxacum officinale*	10
Seed of *Betula verrucosa*	1. 6

The mean dispersion limit is defined as the distance from the plant beyond which less than one one-hundredth of the seed or pollen will reach.

Other chapters in the book are devoted to questions relating to atmospheric electricity, vertical wind distribution, dissipation of energy in the atmosphere, etc. The book is pleasingly written and deserves all attention from meteorologists and others interested in atmospheric phenomena.—*C. G. Rossby.*

[1] Der Massenaustausch in freier Luft und verwandte Erscheinungen, von Dr. Wilhelm Schmidt, Hamburg 1925. (Probleme der Kosmischen Physik, VII.)